

TECHNICAL MEMORANDUM

TO: Sue Eastman, U.S. Environmental Protection Agency

FROM: Rone Brewer, Washington Waterfowl Association

DATE January 25, 2013

**RE: TECHNICAL COMMENTS ON THE
HYDROGEOLOGICAL EVALUATION OF PROPOSED
LEQUE ISLAND RESTORATION**

INTRODUCTION

The Hydrological Evaluation of Leque Island Restoration (i.e., the groundwater study) was completed by Pacific Groundwater Group in December 2012, evaluating the implications of Leque Island dike removal and intertidal restoration on seawater intrusion into the adjacent Island County Sole Source Drinking Water Aquifer. The Washington Waterfowl Association (WWA) has reviewed this evaluation and herein provides general and detailed technical comments.

In direct regard to the subject matter of the groundwater study, and in support of our Leque island project partners, the WWA is concerned herein only with the potential impacts of seawater (chloride) intrusion into the drinking water of northeast Camano Island residents. This does not reduce or lessen our concern regarding other contractual, recreational, management, and agricultural use matters related to Leque Island restoration.

In summary, the body of the groundwater study is written in a manner with little substance and lots of discussion, with the purpose of convincing casual readers of the provided conclusions. Close examination suggests the conclusions are based on short-term, unrealistic, non-protective conditions and model assumptions, and salinity and flow in deeper groundwater is ignored in most discussions. The groundwater study was conducted, but none of the model input variables were measured for Leque Island, and very few of the measured groundwater properties measured in the monitoring area were used in the groundwater flow model, allowing selection of unrealistic and non-protective model input variables. Specifically, model inputs were selected that reduce groundwater hydraulic head on a restored Leque Island and increase hydraulic head elevations in the areas underlying the monitoring area and Camano Island uplands. This selective model input selection includes:

Leque

- Increased head contribution due to higher elevation western restoration area boundary (high estuarine marsh condition) not accounted for;
- Consideration of all water over 7.1 ft elevation as runoff and related loss of hydraulic head pressure of tidal inundation.
- Selective consideration of silty soils as a deterrent to water intrusion, but not as a barrier to drainage into hypothetical created drainage ditches;
- Elevated evapotranspiration value under restoration conditions;

- Slice 2 K_v seems too low;
- Inclusion of filled Leque Island drainage ditches as drain cells;
- Created channel drain cells are too wide/modeled as unrealistically efficient;
- Lack of consideration of siltation in the restored area;

Camano Island

- Predicted upwelling may be an artifact of shallow/deep well placement adjacent to drainage ditches;
- Assumption that all groundwater flowing to the vicinity of Well N3S is discharged to ditches;
- Lack of a measured groundwater elevation between McIntyre and Oksendahl wells;
- Drawdown wells are all distant from the monitoring area, lessening their potential effect;
- Assumption that domestic water withdrawal becomes equivalent recharge in Aquifer D;
- Lack of consideration that measured salt concentrations may be related to elevated groundwater flowing from unplanned restoration of north Leque Island.
- Lack of knowledge of long term groundwater elevations underlying Camano Island upland/Affect of abnormally wet 2012 spring on Camano Island groundwater elevations.

It is our conclusion that modeling using more realistic and long-term (i.e., likely future, and groundwater protective) conditions would show higher groundwater head levels on and/or adjacent to the restored Leque Island, and lower groundwater levels underlying Camano Island. These problems highlight the need for abandoning the Leque Island intertidal restoration project, or conducting a multi-year investigation with more hydrogeological measures taken on Leque Island and Camano Island, as originally required by the Camano Water Systems Association and Juniper Beach Water District.

Yet, even with the above model shortcomings, the groundwater study results show there will be high salinity groundwater flow into the legally-protected dedicated Island County Sole Source Drinking Water Aquifer and Juniper Beach Water District Drinking Water Recharge Area that is well-defined in an established Drinking Water System Plan approved by the Washington State Department of Health. This is illegal and cannot be allowed to occur.

GENERAL COMMENTS

It seems environmental factors (very wet spring and related elevated groundwater recharge), and selected groundwater model factors (salinity, drain cells, distant groundwater withdrawals over a mile from the monitoring area, purported septic and irrigation recharge through glacial till, tidal runoff above 7.1 ft, sea level rise, etc.) all result in underestimation of the potential for effects of Leque Island restoration on Camano Island drinking water; more specifically, an underestimation of salinity and hydraulic head level on Leque Island and overestimation of long-term groundwater elevations underlying the Camano Island uplands. Given only 0 to 6 inches of head difference between modeled future Leque Island groundwater levels and this year's elevated (very wet spring conditions) Camano Island groundwater levels, under more realistic long-term conditions Leque groundwater head elevations could well be higher than the Aquifer D drinking water wells shown in this study. This indicates there is a likelihood of groundwater flow from Leque Island toward Camano Island.

A groundwater study was conducted, but essentially none of the groundwater model inputs were measured for Leque Island. Rather, the model inputs are all estimated. Why weren't good quality model input data gathered regarding the properties of Leque Island?

Regardless of use of non-conservative model input conditions and lack of consideration of long-term changes on a restored Leque Island, the groundwater model still shows groundwater flow into the protected Sole Source Drinking Water Aquifer from Leque Island. This is illegal. EPA modeling guidance requires the use of Reasonable Maximum conditions when modeling risks.

The groundwater study/model is temporally static, and does not consider long term changes in Leque Island groundwater levels, sea level rise, and groundwater salinity as a result of the proposed restoration. Over the long term, the restored areas of Leque Island will increase in elevation due to siltation. Clear evidence of this is shown by the siltation of the south end of Davis Slough and formation of a complete beach ridge between Leque Island and Camano Island over past 20 years. As the land elevation of Leque Island increases due to siltation, the "groundwater" elevation on Leque Island will also increase. Until a time (which may never occur now given the lack of flow and related silt deposition from the adjacent forks of the Stillaguamish River) when the elevation of Leque Island land surface reaches mean higher high tide, and is then most often above high tides (similar to the area along Davis Slough), the result will be a slow but steady increase in groundwater levels on the restored Leque Island.

An unusually wet spring of 2012 may have resulted in higher than normal groundwater elevations underlying Camano Island. Normally ephemeral streams showed abnormal flow deep into and even through the summer. Similarly, groundwater underlying Camano Island may have been unusually high this past year. The affect of precipitation on an annual and monthly basis is reflected by the rise and fall of groundwater elevations shown in Figure 3-16, and in particular for the months of June and July. The bump in groundwater elevations in June and July also shows that the groundwater levels are considerably influenced by precipitation, and also shows the monitoring area is a recharge area. Without the unusual precipitation, groundwater elevations, including within the Camano Island Oksendahl well, may have been considerably lower. Yet, after restoration, Leque Island groundwater hydraulic head level will remain essentially constant throughout all years, regardless of precipitation, at about 7 ft NAVD88 or higher. This is already as high, or higher, than is shown in the Aquifer D drinking water wells on Camano Island, and could be much higher during normal and dry precipitation years, and into the long-term future.

The study does not meet the original EPA study design requirements. Groundwater levels are only available for 9 months (and not during the lowest annual groundwater elevations), precipitation correlation was measured for 9 months, EC is only measured in groundwater for 5 months and in surface water for 2.5 months, and tidal co-variation is provided for only ten days at moderate tides. We have only two well areas where salinity concentrations were measured at only two depths each; not several representative wells with salinity measured every 10 ft or so down to 100 to 200 ft. as was originally proposed by EPA. Many wells, in particular the only Leque Island well, were placed adjacent to drainage ditches, contrary to EPA recommendations. This does not meet the USEPA study design.

Three months are missing from the groundwater elevation monitoring data. In particular, the lowest groundwater levels of the year are missing, including from the Oksendahl well which was dropping below 7 ft NAVD88 in mid September (Figure 3-13). After restoration, the groundwater on Leque will be above 7 ft NAVD88, essentially all year around. Therefore, during three to four months

out of the year, groundwater on Leque Island are predicted to be higher than in the Oksendahl well, as well as higher than three of four other residential wells farther west on Camano Island. If the high spring precipitation resulted in elevated groundwater levels underlying Camano Island, then future, restored Leque Island groundwater head levels could be well above Camano Island groundwater levels. This was not examined or even mentioned/discussed in the groundwater study.

Assumptions for the groundwater salinity and elevations/flow are not conservative enough to represent actual conditions. Additional model runs are necessary to correct items such as existing drainage ditches being filled instead of being drain cells, salinity up to 5 parts per thousand higher than modeled (as measured and shown for South Pass in Figure 3-6 of the Battelle hydrodynamic study), and head pressure of high tides up to 4 ft above the land surface on Leque Island, rather than being modeled simply as runoff if above 7.1 ft NAVD88. In addition a full 12 months of data should be collected during an average rainfall (rainfall pattern) year to better understand the annual groundwater cycle underlying Camano Island, and annual inter-relationships of groundwater elevations with measured factors.

SPECIFIC COMMENTS

Page 1; Section 1; Paragraph 1; Third Sentence: According to relatives of Nels Leque, he began farming Leque Island in about 1876 without the construction of dikes. Over time, to increase the farmable area, low “pony” dikes were first created shortly thereafter, by a horse-drawn angled blade, much like a modern road-grader. Dikes were gradually raised over time and may not have reached elevations similar to current levels until the 1930s. This approach was possible because the elevation of a significant farmable portion of Leque Island was well above mean high tide back in 1876. Since the initial pony dike was built, the land inside the dike has subsided approximately 5 feet.

Page 1; Section 1; Paragraph 1; Last Two Sentences: This is a groundwater report. The significance of the loss of ecological services, and whether the site is the best candidate for restoration, are judgments outside the scope of the groundwater study. In addition, the reference (Snohomish County, 2012) is not provided in the reference section.

Page 1; Section 1; Paragraph 2; Second Sentence: How was the average of 5 hrs inundation per day calculated? The Battelle hydrodynamic study states tidal inundation will last 4-7 hours, but no explanation is given for how this was calculated. It seems

Page 1; Section 1; Paragraph 2; Third Sentence: The Battelle Hydrodynamic executive summary, in bullets six and seven states:

“Tidal currents within the restoration site are small, generally less than 0.2 m/s.”

“Sediment types in the Leque Island area are fine sediments, mainly consisting of mud. Based on the sediment type information, critical shear stress for erosion is estimated as 0.1 Pa. Results indicate that the bottom shear stress distributions in the restoration site are smaller than 0.1 Pa during most of the tidal cycle. Therefore, it is unlikely that erosion would occur in the Leque Island restoration site after the restoration action of setting back the south dike to the midway point of Leque Island. “

Therefore, the Battelle study shows that after dike removal, the potential for water velocities capable of channel forming processes (e.g., scour) will be present only during a few moments as the last bit of water flows out of the bottom of the existing (or to be excavated) south-central Leque ditch. Ditches will not form due to tidal action. Given Leque Island's location at the mouth of the river and head of a 10-plus mile open water fetch coming up Port Susan Bay, and the formation of a beach ridge across the northern extent of Davis Slough over the past 15 years, the likelihood of more intricate channels forming is quite small. WWA has repeatedly pointed out this fact and yet channel formation continuously shows up as a virtue of Leque Island restoration. Look at the tide flats outside of Leque...there are no channels other than the river and the old Davis Slough channel, both of which are silting in. It is inappropriate to make broad statements such as "intricate channel formation" will occur, without facts to support the statement. Provide the evidence that it will occur or don't bring it up as a "potential" virtue of the project.

Page 2; Section 1; Paragraph 1; Last Sentence: Concerns for groundwater contamination are two-fold. First, is salt intrusion occurring into the sole-source drinking water aquifer. Second, is salt reaching drinking water wells. The statement that the model predicts no "...further groundwater salinization under Camano Island", needs clarification. In this statement, is "Camano Island" inclusive of the fields west of Land's Hill but east of Davis Slough? In the document there are many different names used for the different area so it is impossible to interpret this statement with regard to both concerns above. Does this address the potential for deeper westward groundwater flow.

Page 5; Section 3; Paragraph 1 and Paragraph 3: Confusion is created by naming the various areas of investigation. Multiple names for multiple areas are used inconsistently throughout the report. What is the definition of "Camano Island"? It seems that in one case you are excluding the agricultural fields west of Davis Slough from this use of "Camano Island". In Section 3.3.1, the "eastern margin" of Camano Island is introduced. There was "northeast" Camano Island presented earlier, now there is the "Monitoring Site" and "Grazing Land". Monitoring Site is the only one of these on Figure 1-1. In Section 3.2, the term "study area" is introduced and has not been defined. Please be completely clear and consistent throughout the document in regard to the extent of each of these area names and how each relates to groundwater flow.

Page 5; Section 3; Paragraph 4: Is there evidence for the claim that "shallow" mainland groundwater is "expected" to flow toward and into the river. No support, data, citations, nor references are provided. What about deeper groundwater?

Page 5; Section 3.1; First Paragraph: No reference is provided for the weather quote. Where was it copied from?

Page 6; Section 3.2; First Paragraph; Second Sentence: What groundwater, from where, discharges to the various marine and inland surface water.

Page 6; Section 3.2; First Paragraph; Fourth and Fifth Sentences: What is the pertinence of the fourth sentence? There are hundreds of feet of unconsolidated sediment underlying Leque Island that built up over time. At one time Leque Island was valley...or a river channel, and indeed, once were intertidal. But not in the late 1800s. In 1919 much of what is now Leque Island was mapped as uplands or very high estuarine wetlands, likely overtopped by very occasional extreme

high tides, but most often by freshwater flooding from the West and South Passes of the Stillaguamish River, which at that time carried most of the water (and sediment) in the river system. It is precisely the relatively high elevation of Leque Island in the 1800s and predominant rain and freshwater overtopping likely helped support development/expansion of the freshwater aquifer to the west, along Camano Island. The Leque family built a home and farmed portions of Leque Island before dikes were built (Personal communication with 90 year old farmer who knew and farmed for the Leque family). In the natural order, as the land was farmed, it subsided. To account for subsidence and expand the farmable area, dikes were slowly built up over time. Now the land has subsided considerably since farming began and is several feet lower than land outside the dikes, which is up to 13+ feet elevation (MLLW), with a complete beach ridge now present along the shoreline between Leque and Camano Islands at the south end of Davis Slough.

The dikes have very rarely overtopped, and any overtopping was not enough to overfill the drainage ditches. Complete lack of maintenance of the Leque dikes has resulted in a few dike breaks since Washington State Fish and Wildlife took over. Dikes never broke on private ground where they were maintained. Other than the breach on south Leque Island in 2010 that was only “patched” and remains only patched to this day, the earlier breaks resulted in very short term inundation with salt water and farming the next year. An unmanaged dike was purposefully allowed to break on north Leque Island and that area has reverted to low estuarine marsh, two to three feet lower than all the surrounding marsh (due to subsidence while enclosed in the dikes).

So, the implication in the text of the report that there has somehow been long term contribution of saltwater into the groundwater of south Leque Island (the “Study Area”?) due to overtopping and breaches, is not true.

Page 6; Section 3.2; Second Paragraph: The ditches on Leque Island are quite stagnant during the summer due to the lack of flow. This stagnance and evaporation produces aquatic algae growth and very poor water quality. How do these conditions affect the measures of electrical conductance in the ditch? How did the multiple failures of electrode conductance probes affect the results? How were the probes calibrated? This information is not provided in Appendix A.

Page 6; Section 3.2.1; First Paragraph; Second Sentence: Tides regularly exceed 11 ft NAVD88 during the winter. If the statement regarding tides greater than 10 ft is meant to infer tide level during this study, or is referring to tide level data gathered during this study, please clarify.

Page 6; Section 3.2.1; First Paragraph; Second to Last Sentence: West pass is impassable in a kayak at about a 0' NAVD88 tide level. A few deeper sections of narrow channel exist along small cut-banks. Upstream of the new SR532 bridge the channel gets shallower with fewer if any pools due to the straightness of the channel.

Page 6; Section 3.2.1; Second Paragraph: The Battelle hydrodynamic study predicts salinities from 8 to 20 ppt on Leque Island under restoration conditions. Generally, this compares favorably to the range of measured concentrations in some of the ditches, but not in the north ditch, nor Davis Slough. This is a bit counter-intuitive. Measured concentrations seem lower than would be expected in the slough as there are no large distinct freshwater inputs. And measured EC concentrations in the ditches that are twice that found in Davis Slough is very unexpected. Where would salt be coming from that is so high compared to Davis Slough? It seems possible that lower EC concentrations in the north ditch reflect freshwater input from the spring at the base of

Land's Hill. Could poor water quality in the ditches be impacting the EC measurements in these ditches? What calibrations were done to verify the EC measures were accurately measuring salinity, particularly in ditches with very poor water quality like the Leque Ditch. Were the EC measures sensitive to temperature? If so, was temperature sensitivity calibrated/accounted for?

Water levels at the middle ditch mirror Davis Slough. This is expected given tidal effects on tide gated outlet located very near middle ditch sample point. Water level data also show that during wetter times (precipitation), water from south and north ditches flows to and accumulates at middle ditch before release into Davis Slough at low tide. Again, this is expected. Yet EC/salinity in middle ditch is the highest of all the ditches; this seems counter-intuitive given the dilution that would be occurring from lower salinity ditches flowing into middle ditch. Similarly, if lower concentrations of salinity from Davis Slough or Port Susan Bay were the cause for salinity in the south, middle, and Leque ditches, how could the concentrations in the ditches, which are flushed with fresh water all winter, be higher than the slough or the bay?

How were salinity data used in the investigation? This is not described in the methods section?

Without much more information and analysis, the EC data appear to be relatively useless for making any predictions of interactions between.

Page 6; Section 3.2.2; First Paragraph: As noted above, the bottom elevations in Davis Slough do not seem correct given slough bottom measure of 0' by WSDOT at the Davis Slough Bridge.

Page 6; Last Paragraph & Page 7 First Paragraph: Higher elevations of water in ditches with distance from a tide gate are a purposeful design factor and required for drainage to the tide gate. There is no evidence of ditch blockage. In fact, the lack of longer term elevated water levels throughout the entire monitored period, and the presence of short term water level increased accompanied by increases in middle ditch (such as shown for July 4 and 5) and no increase in tide height on the same days, strongly suggests just the opposite; that is, north and south ditches are flowing quickly to middle ditch and middle ditch backs up a bit until the tide gate opens, then drains down until the tide gate closes. During higher tides (and likely wetter periods), enough water backs up to affect elevations in north and south ditches; again perfectly normal, and actually indicating good ditch flow.

It needs to be clarified here that the "tidal influence" here is solely how tides affect opening and closing of the tide gate.

There is no evidence of differing sensitivity to high-tide events other than through closing of the tide gate and different ditch elevations upstream of the tide gate.

The Leque ditch shows no tidal variation because it is about 2/3 of a mile to the nearest culvert and over a mile to the other culvert. This sample location is also at the dead-end head of drainage and receives no upstream channelized inputs. There is no evidence whatsoever provided that the drainages on Leque are blocked. A one hour walk of the island would have confirmed this. Simply, the Leque ditch sampling location is upstream far enough in the ditch system, that tidal-related opening and closing of the culvert doesn't influence water levels at the sample point.

It must be noted in the document that the temporary dike fixes on Leque Island leak at every high tide. Thus, an abnormal (to diked conditions) flow of water and possibly salinity are entering the

island through this route every day. In fact, the presence of surface water on Leque Island, particularly since the northwestern culvert was replaced last year, are primarily the result of this leakage. Thus, because all the ditches on Leque Island are directly connected to each other, this leak of south pass water into the island likely influences ditch levels and salinity. This affect would be less in the summer because of the generally lower average tide levels and the resulting reduced opportunity for leakage through the dike fix area.

How did all this ditch water level information inform the groundwater model? Given the above comments are counter to conclusions made in the report, what conclusions are made from ditch elevation data that may need to be re-evaluated.

See comment on Figure 3-4 below.

Page 7; Second Full Paragraph on Page: How are fluxes used in the modeling? What flux data are used for conclusions in the report? Please explain why is flux data important and/or pertinent to the study.

Page 7; Third Full Paragraph on Page: In regard to Electrical Conductivity (EC), also see comments for Second Paragraph of Section 3.2.1 (Page 6) above. The reasons for higher EC in some ditches could be related to groundwater discharge, or could be related to poor water quality. The lack of EC calibration or results from unimpacted stagnant ditch water makes it impossible to be sure. Stagnant water/poor water quality and spring-fed inflow to north ditch appear to correlate well. The rationale provided for higher EC in the “intensively” monitored area is unsupported in that if infiltrating groundwater and past saltwater inundation were the reason for increased salt in some ditches, we would expect the Leque ditch to have much higher EC than the south and middle ditches because salt water has been on and over Leque Island repeatedly and/or constantly since the dike breach in 2010, whereas there have been one or two short term inundations of the monitored area in the past 30 years. The whole concept of residual salt in the soil being carried by groundwater needs much more research and or support before it seems plausible give the above.

The last sentence of this paragraph correlates EC in Davis Slough with the north ditch, but a few sentences before it is stated that Davis Slough EC is clearly not related to ditch EC. What is the purpose of this sentence? It should be omitted or moved up such that the conclusions regarding Davis Slough EC impact on ditch EC comes after this sentence, closing the issue.

Page 7; Footnote: This footnote discusses rationale and conclusion that should be in the text. How do you know that the salinity-to-EC ratio for groundwater? This ratio development is not discussed or presented anywhere. Also, you are comparing “reported” seawater ratio with measured on-site groundwater ratio and no (measured/reported) ditch ratio. Then the reported conclusion is that only groundwater could cause measured EC in the ditches. What is the reference for the seawater EC ratio provided? Was it for open ocean or brackish marsh? Brackish marsh and particular tidal sloughs carry a significant quantity of sediment and organic matter; because of this they are also notably lower in dissolved oxygen and possibly higher in ions than open ocean water. Can any of these additional parameters in Davis Slough or the ditches impact EC measurements. If you determined site-specific EC-ratio for groundwater, why didn’t you determine it for Davis Slough and Ditches so we could make a direct comparison? Is calculated salinity-to-EC ratio the same for groundwater on Leque as it is for groundwater underlying the monitoring area? If so,

then it is evidence of connection...if not, then there may be salinity coming from somewhere else. Giving one ratio and making a conclusion doesn't seem possible from the data provided here.

Also, the conclusions that groundwater is discharging to ditches is the purpose of the ditches. Is there salinity in groundwater that is deeper than the ditch bottoms that is not discharging to the ditches?

Page 8; Section 3.3.1; Second Paragraph: Referring to the descriptions in Tables 3-2 and 3-3 as "detailed" is inappropriate. Tables 3-2 and 3-3 provide generalized descriptions from the USGS soil series descriptions. Detailed conditions would be those from actual wells, which for Leque and Camano lowlands, show discontinuous silts of unmeasured/unknown permeability, with interbedded sands and gravels, to a depth of over 200'. It is clear the stratified geological nature underlying Camano (e.g., Figure 3-9 and last paragraph on Page 8) does not continue into the Camano Island lowlands or onto Leque Island. How these two geological formations come together is critical to understanding groundwater flow from Leque to Camano, and it was not investigated.

Also, the difference between Q_a and Q_m in the study area is likely to be the result of tilling over the past 100 years. Leque has been tilled until recently, and so may very well be similar to the Q_a across the Stillaguamish River.

Page 9; Section 3.3.1; First Full Paragraph: Considering the silt overlying much of the Leque and Camano Island lowlands as a "confining" layer is inappropriate. These silts are likely less permeable than sands and gravels, but are still permeable and saltwater over the top of Leque Island will result in saltwater in groundwater underlying Leque Island. How did the reported "confining" nature of these silts affect model inputs? It is unclear here and elsewhere in the document how groundwater model inputs were determined through these discussions. Clarification is needed in these report sections as to how these discussions resulted in specific model inputs.

Page 9; Section 3.3.1; Second Full Paragraph on Page; Last Sentence: This is an example of unfounded study assumptions leading the reader, and possibly influencing the model inputs and results to a finding of no westward groundwater flow from the mainland, and therefore, no impact to Camano Island groundwater due to the flow of water westward from Leque Island toward Camano Island (particularly deeper groundwater). The Stillaguamish River only cuts into the aquifer **IF** the unverified assumption by WSDOT is true, that the river has a bottom elevation of -5 ft NAVD88. The uncertainty is shown as a dotted line in Figure 3-10, but this uncertainty is completely omitted from the statement in this sentence. Just a glance at the estimated channel shape shown in Figure 3-10 shows the reader the assumption is unrealistic as tidal river channels are not shaped like this. The reality is that slightly deeper parts of the river channel are along the outside corners of West Pass, north of the study area. It is completely possible, if not likely, that the river does not directly intersect the aquifer along South Pass, which is shallower than West Pass where the WSDOT took its measures. Why wasn't the South Pass river bottom elevation not measured during the groundwater study?

Page 9; Section 3.3.2: Are the aquifer properties listed in this section used as model inputs? The only aquifer properties we gained from the study were those in the well the farthest from Leque Island? Why was the well pump test conducted at Well N3S, the farthest possible distance from

Leque Island? Why wasn't a pump test conducted at Well N2S and/or N2D so we could get a relationship between shallow and deeper groundwater? Does pulling shallow groundwater out of a well result in a high flow of deeper groundwater. Is deeper ground salinity higher showing a very shallow freshwater lense underlying the study area? Why wasn't a pump test conducted at N1S so we could understand Leque Island conditions? The lack of specific easily obtainable measures across multiple wells belies the completeness of what was already a very limited groundwater study, and renders the results questionable.

Page 10; Section 3.3.3; First Paragraph; Fifth Sentence: The lack of measured elevations of groundwater and salinity within the WSDOT wells (particularly BH-3P-11 and BH-4P-11) is a critical failure that could have been resolved simply. This data could have informed us of the implications of tidal flooding that is occurring on North Leque Island. Regardless, Figures B-1 through B-5 would seem to show that other WSDOT wells (2P, 3P, and 15P), adjacent to the flooded north Leque Island have water levels higher than ALL other lowland water level measurement locations throughout the year (except for some months at well S2S). Why wasn't this presented/discussed? This data strongly suggests that the flooding of formerly diked lowlands raises the groundwater head level above areas that remained diked. Based on these figures it would seem groundwater would currently flow southwest, possibly under the eastern upland portion of the Camano Island uplands, and possibly out into Port Susan. This figure also shows that during a high groundwater recharge year, modeled water levels on a restored Leque Island would be the same as water levels in the Oksendahl well underlying the Camano Island uplands. Are water levels in these wells used in the groundwater model?

Page 10; Section 3.3.3; Third Paragraph: The details of water density calculations could have significant effect on study results. How were the water density corrections calculated? What corrections were made? Do we already have "brackish" groundwater? What is the definition of Brackish in this sense related presumably to EC? None of the calculations are provided in Section 3.3.5 as cited in this paragraph and are not in Appendix B.

Page 10; Section 3.3.3; First and Second Bullets: Well N3S is not "nearest" to the "middle" ditch sample location. Well N2S/D is immediately adjacent to the ditch and nearest to the middle ditch sample, and groundwater in this well is nearly 2 feet higher than the middle ditch. Well N3S is in the middle of a field, not near any ditches so it is unclear how it could be more connected to the middle ditch than N2S/D. This same condition is found and described in the second bullet for S1S/D and the "South" ditch sample location and the reason given is that there is considerable "skin" resistance between the ditch and groundwater. Yet the conclusion provided is that groundwater, particularly from N3S, appears to discharge to ditches, contrary to the description provided in the second bullet and given N2S and middle ditch water levels shown in Figure 3-12. Thus, the statement that N3S is likely to discharge across a field to "middle" ditch is wholly inappropriate and unfounded. The underlying implication of this statement is that groundwater is discharging to the ditches, thus eliminating the head pressure exerted westward toward the Camano Island uplands. But, if groundwater immediately adjacent to the ditches is nearly two feet higher than surface water in the ditches, then the connection between N3S and middle ditch would seem to be marginal at best, or maybe the elevation measurements were incorrect. Maybe the earlier described "silt" layer near the ground surface is limiting flow from groundwater to the ditches and the full hydraulic head from the north, west, and south is pushing toward Camano

Island with little to no release to the ditches? How did this conclusion of groundwater discharge to the ditches within the monitoring area affect the model input variables? It would seem more information is needed regarding the interaction of ditches and groundwater within the monitoring area.

Groundwater levels at N3S are the lowest in the monitoring area and all surrounding well water levels are higher. The variability in water levels in individual surrounding wells ranges up to one foot (2P-11) and about a third of a foot closer to N3S. Yet the variability in Well N3S is only 0.08 ft. How is it possible that a well receiving water from all these other daily varying inputs is so stable? All the incoming water has to go somewhere quickly. Yet, the N3S well log shows sands and silts, the well is approximately 200 feet from all ditches, and all available evidence is that groundwater supposedly discharging to ditches is nearly 2 feet higher than immediately adjacent ditch water levels and nearly a foot (or more) higher than in Well N3S. Because the middle ditch location is so impacted by tides and would be influenced by the “north” and “south” ditch flows, it is not possible to estimate or correlate Well N3S influence on the middle ditch location. But, assuming 18 ft/day conductivity reported earlier, one would expect at least a 10 day delay between significant rainfall events and any ditch elevation increases (unless there is a surface connection), and this is not evident from the precipitation data provided in Figure 3-16. Rather, the precipitation data show a possible 1 day delay in middle ditch water elevations following rainfall. This suggests that Well N3S is not releasing significant quantities of water to the middle ditch. Verification of groundwater flow from Well N3S to a drainage ditch would require measurement and water level monitoring of the central ditch upstream and west of the current “Middle” ditch.

But we must also ask, where else could the water go? All of the hydraulic head contours west of N3S (Figure 5-2) are based on the McIntyre and Oksendahl groundwater levels, which are about one-half mile apart and approximately equidistant (approximately 1,000 horizontal feet) from the lowest groundwater elevations modeled in the vicinity of Well N3S. Thus, the modeled groundwater elevations along the base of the hill in this vicinity are not accurate. Given the subsurface gravel lenses seen in Well N3S and in several wells north (BH-8P), south (S2S), and west (Vaughn and Whitney) of N3S, it seems possible a similar high permeability layer is present along the base of the Camano Uplands/Lands Hill. If present, groundwater from the vicinity of N3S could be flowing westward under the Camano Island uplands. Regardless of the outlet for groundwater from the vicinity of Well N3S, given the lack of daily variability in groundwater elevations, the outlet would seem to be relatively highly permeable.

The reason the WSDOT wells have higher groundwater elevations is because north Leque Island tidal flooding just across SR532. This is definitive evidence of groundwater elevation caused by “restoration”. And the elevations shown in the WSDOT wells significantly exceed the modeled Leque Island restoration groundwater elevations. These comparisons are essentially a calibration showing the model results are not representative of future Leque Island restoration conditions.

The first bullet also clearly states that groundwater is shown to flow into the Sole Source Drinking Water Aquifer. Isn't this a violation of the purpose of a sole source drinking water aquifer?

Page 10 Footnote: The statement that water level elevations vary because of restrictions in the ditches is unsubstantiated and unfounded. Were ditch bottoms measured to determine whether they were at same elevations and whether water depth/volumes were similar? A simple walk of the ditches would determine any blockages, which are unlikely in the monitoring area where agricultural/pasture uses require drainage.

Page 11; Section 3.3.3; First Bullet on Page: The McIntyre well is likely a recharge area with an apparent mound of groundwater, influencing flow within a small portion of Aquifer D. In fact, the model groundwater head contours shown in Figure 5-2 shows flow due north toward the Oksendahl well, not toward Well N3S. It is quite possible that the Oksendahl well is similar and flowing toward a lower hydraulic head elevation between Oksendahl and McIntyre. If this were the case, groundwater from N3S may well flow west toward the same low.

Please provide the Island County groundwater elevation data for a weight of evidence analysis, with consideration of the uncertainties of its use. The Geodesign data for Leque Island were provided and are also not contemporaneous. Why the selective use of historical data?

Page 11; Section 3.3.3; Third Bullet on Page: What are the vertical gradients on Leque Island? Not measured? If they were to suggest downward flow, the restoration would carry saltwater downward, possibly to be brought back up in the monitoring area, bringing saltwater into the dedicated Sole Source Drinking Water Aquifer.

The N2S/D and S1S/D wells are all immediately adjacent to drainage ditches. It seems quite possible this allows relief of head pressure in the shallow well, resulting in the measured head pressure differences between shallow and deep wells?

Page 11; Section 3.3.3; First Non-Bulleted Paragraph: Water apparently flowing to the low lying vicinity of Well N3S must go somewhere. Discharge to ditches is a reasonable possibility, but the ditch elevation data compared to Well N3S water elevations do not clearly support a ditch discharge. More data is necessary to verify or refute this possibility. Another possibility is a westward flow path under the Camano Island uplands.

Also in this paragraph and the following paragraph is the oft-cited likelihood of ditch blockage. Please stop using unverified site conditions as a reasonable refutation of unexplained factual evidence. Walk the ditches and document the blockages or don't use the argument. It seems you have forgotten that during the entire groundwater study period, the temporary dike fixes on Leque Island have leaked salt water into the field that is drained, in part, by the "Leque" ditch.

Page 11; Section 3.3.3; Last Paragraph on Page: The WSDOT wells are directly across SR532 from the tidally influenced north Leque Island. It is pretty straightforward and quite clear that the tides in this "restored" area influence groundwater levels in the WSDOT wells all along SR532. The elevations shown in the WSDOT wells significantly exceed the modeled Leque Island restoration groundwater elevations. These WSDOT groundwater elevations provide a real-world calibration demonstrating that the groundwater model results are an underestimation of future Leque Island restoration groundwater elevations.

Page 12; Section 3.3.4; First Paragraph: there are no septic system nor agricultural irrigation in the monitoring site, only on the Camano Island uplands. The geologic subsurface descriptions provided in the groundwater study show that the Camano uplands are predominantly underlain by impermeable layers above Aquifer D. Thus, it seems unlikely that septic system and irrigation waters provide significant recharge to Aquifer D through these impermeable layers. Rather, the water flows over the top of the shallower impermeable layers and either directly into surface water bodies as mentioned or, in the vicinity of the monitoring area, the water flows off the uplands to a lowland Aquifer D recharge area. Thus, for the most part, the removals are simply removals and result in overall drawdown of Aquifer D.

Page 12; Section 3.3.4; Third Paragraph: Infiltration is 1.4 to 4.8 inches per day? This is orders of magnitude higher than 0 to 8 inches per year provided in the previous paragraph? Is this correct?

Page 13; Section 3.3.5: As discussed above, the various EC results for ditches, Davis Slough, and groundwater, and all the troubles experiences with the EC probes likely make the data unusable. How could ditch salinity be higher than Davis Slough? Residual salt in the soil should be diluted at least to a level Davis slough/Port Susan concentrations so this is not likely the source of elevated EC in ditches and groundwater. Rather, it seems very poor water quality conditions affected the EC readings in ditches. How could the North Ditch water with all the freshwater from the Spring still have the same salinity as Davis Slough? How could groundwater in N1S, N2S and N3S all be twice that found in Davis Slough? And then S3S, reportedly in a groundwater recharge area has EC values similar to Davis Slough.

Salinities in groundwater are reported as being similar to salinities in Skagit or Port Susan Bays? Could the north Leque Island “restoration” resulting in high groundwater levels adjacent to SR532, be flowing south, causing the extremely high EC in all the north transect wells? It seems that after two years of partial flooding and four years of full flooding on north Leque Island, and given 18 ft/day conductivity, the saltwater intrusion from North Leque could easily have already reached the monitoring area, already contaminating the dedicated Island County Sole Source Drinking Water Aquifer.

S3S is in a reported upland influenced recharge area, yet has EC values just below those of Davis Slough?

N2D has the same EC as Davis Slough? And this groundwater is rising (vertical gradients) and leading to a doubling of the EC concentrations at the surface?

It is impossible for a log jam at Davis Slough Bridge to cause an overflow into the adjacent fields. Logs have to float to get to the bridge and there is essentially no current in Davis Slough other than dead end tidal currents. Water would flow easily under the logs until such time as the tide dropped below dike elevation. This being said, there have been some dike overtoppings through the years and maybe a dike break at the south end 30 or so years ago, but it seems very unlikely that these result in soil salt content high enough to result in the groundwater. Without verification, the arguments provided seem to be a weak attempt at obscuring the fact that salt contaminated groundwater higher than Davis Slough is entering the Sole Source Drinking Water Aquifer.

Were shallow soil samples collected and tested for chloride content? This would be a simple test to verify the possibility of residual salts creating the brackish groundwater conditions.

Page 14; Section 4.0: Absolutely no evidence has been provided that the ditches are clogged or blocked. Water still drains from the recently replaced northwest and the older southeast tide gated culverts. If the ditches are clogged beyond flow, where is this water coming from? The continued use of this rationale without evidence undermines the credibility of the groundwater study.

Page 14; Section 4.1; First Paragraph: What data are available to show groundwater levels are "...possibly several feet lower during the dry season..."? If it is available data, what is the citation?

Why weren't direct measurements of salinity available after a Leque Island Groundwater Study?

Given tidal leakage through the partially repaired dikes that have been leaking for nearly three years, salinity concentrations in the "Leque" ditch are highly unlikely to represent conditions before the 2010 dike breach, and certainly don't represent salinity under normal maintained dike conditions.

Page 14; Section 4.1; Tidal Inundation: Batelle Hydrodynamic Study says flooding by tides will be 4 to 7 hours. A conservative assumption would be flooding 6 or 7 hours, not an average of 5 hours.

Page 15; Section 4.1; Drainage Network Development: The Battelle Hydrodynamic Study clearly shows the post-restoration tidal current velocities will not be adequate to develop any channels. What is built is what will stay, until it silts in due to the sedimentation from Port Susan to the south.

Page 15; Section 4.1; Expected Salinities: The Batelle Hydrodynamic Study provides a calibration that shows actual salinity will be about 5 ppt higher than modeled.

Page 15; Section 4.1; Land Cover: The northern portion of Leque Island was farmed in 2012. The inadvertently "restored" North Leque Island is a monoculture of cosmopolitan bulrush, as is much of Port Susan Bay south of the Leque Island. Therefore, it is likely that a restored Leque Island would also be dominated by the same bulrush.

Page 16; Section 4.2.1; Top of Page: "Current" salinities in the Leque Ditch are the result of salt water intrusion through a partially repaired dike and may well approximate post inundation salinity, but the EC measures taken during the groundwater study appear to be fairly unreliable. There was significant precipitation during the period that the Leque Ditch EC data were collected and therefore, the 11 parts per thousand that was measured had been diluted by rain water and is not a realistic estimate of salinity during a full restoration condition. It is important to note that these conditions (leaking dikes) have existed for nearly three years, but are not indicative of the past 100 years of Leque Island's existence. The implication in this paragraph that current conditions represent "normal" conditions is incorrect. The Batelle Hydrodynamic study shows measured salinity in South Pass as high as 20 parts per thousand. The salinity used for the groundwater model should be at least 15 and possibly 17 parts per thousand.

Page 16; Section 4.2.2; First Paragraph: How exactly will the drainage become more efficient? There have been no measures of the current drainage, nor a detailed plan for the proposed drainage "network".

Page 16; Section 4.2.2; Second Paragraph: Is the recharge 1.4 to 8 inches per day as cited earlier in the document for the monitoring area, or is it 4-8 inches per year as presented in Sumioka and Bauer. Why wasn't this value measured for the groundwater study. Up to more than 4 ft of tidal inundation will present additional hydraulic head pressure on the saturated sediment. In addition, the model does not account for the same inundation against and over the high estuarine marsh habitat along Davis Slough, which is at a higher elevation than Leque Island because of the subsidence of farmland that has occurred in the dike (and sedimentation outside the dike). The restored north Leque Island and groundwater levels in the WSDOT wells just south of SR532 provide an example of likely groundwater elevations in the Davis Slough marsh, except the Davis Slough high estuarine marsh is at a higher elevation than the areas where the wells are placed. Thus, at a minimum, the groundwater level will be up to 7.4 ft NAVD88 (as found in the WSDOT SR532 wells) and possibly higher.

Page 16; Section 4.2.2; Third Paragraph: The values used as inputs to calculate recharge rate seem too low. If this is a groundwater study, why wasn't the actual recharge rate measured? What rates were measured in the adjacent groundwater monitoring area on Camano Island? Are those reasonable for Leque Island? Why are default and/or estimated literature values used when a groundwater study of Leque Island was just completed? What is the basis for the statement that after saturation to the soil/sediment surface recharge will be rejected. Over four feet of tidal inundation will exert hydraulic head pressure on the groundwater, essentially increasing the vertical hydraulic head to an elevation higher than the soil/sediment surface. The WSDOT SR532 wells show this to be true.

Page 16; Section 4.2.2; Fourth and Fifth Paragraph: The proposed "channels" will be created on only the southern portion of Leque Island. The actual supposed "enhancement" of drainage is unknown because current drainage has not been measured. Natural tributaries are unlikely to form (Batelle Hydrodynamic Study) and siltation, as experienced all around south Leque Island will likely raise the sediment/bottom elevations on a restored Leque Island, over time, filling in most ditches. Deepening of drainage is "likely" to enhance drainage? Will it or won't it? If there is a chance it won't, then the model needs to consider this fact. The groundwater elevations along ditches within the monitoring area were up to 2 ft above the adjacent ditches suggesting drainage ditches on Leque may not have a wide swath of drainage effect on groundwater...in fact, the available site-specific data all shows they may have little to no impact on groundwater levels, particularly in a regularly inundated area.

Page 17; Section 4.2.3; Third Bullet: What is the basis for rejection of recharge where saturation reaches the surface.

Page 17; Section 4.2.3; Second Paragraph: What were the approximated high and low CHD values used? The 3.75 ft channel bottom elevation is nearly a foot lower than existing drainage ditches on the island. In past iterations of the restoration plan, minimal excavation was to be conducted because of costs and time involved. Yet now, without a written restoration plan, the model assumes a large "network of drainage dug to an average of 1 foot below current ditch bottom elevations. This would seem to significantly overestimate drainage, leading to less inundation time/lower constant head over time. Also, a majority of high tides will be above 8.5 ft NAVD88, particularly in winter with a 14 ft tide level recorded this year. Again, the model variables appear selected to minimize the potential groundwater head level and flow away from the island.

The last sentence states the CHD values did not calibrate well, but the “overall” affect is “expected” to be similar. Where is the fact-based justification for this statement? And the effect shown in Figure 4-4 is a potential for increased drainage, again minimizing potential affect of inundation on groundwater resources.

Page 17; Section 4.2.3; Third Paragraph: Assuming all water above 7.1 is run-off underestimates the effect of high tides on the hydraulic head overlying the sediment surface. This would seem to underestimate the infiltration/recharge of groundwater.

Page 17; Section 4.2.3; Fourth Paragraph: Given the hydraulic head pressure exerted by tidal waters overlying the land, it seems the balance of groundwater discharge to the bays would, on average, be deeper than mean sea level. What is the justification for using mean sea level?

Page 17; Section 4.2.3; Last Paragraph on Page: It seems there should be a range of values used and a resulting range of values of groundwater head elevations/recharge reported so that the potential range of recharge can be better understood. It doesn’t seem that recharge data from the adjacent monitoring area used in the model?

Page 18; Section 4.2.3; Table and Second Full Paragraph: What are the references for these values? Where did they come from? The K_v for Slice 2 seems too low; why was 0.2 used here?

Page 18; Section 4.2.3; Third Full Paragraph and Bullets: Available data from the adjacent monitoring period does not support a 50 ft radius of groundwater drawdown around drainage ditches. Drainage is likely overestimated in the model as groundwater adjacent to ditches in the monitoring area was up to 2 ft higher than ditch water levels.

Page 18; Section 4.2.3; Numbered Bullet 1): There are no available data regarding drainage ditch efficiency on Leque Island. None was collected. Researches did not even walk the ditches to make this determination, let alone measure runoff from only two culverts. The appearance of poor drainage is actually due to leaking through the dikes at every high tide. Stop downplaying existing drainage, which, was recently upgraded with a new culvert/tide gate.

Page 19; Table: The estimated future average groundwater elevation around ditches will not extend out to 50 ft from the ditches. Thus, the annual condition portion should be significantly reduced for elevation near ditches and the weighted average should be adjusted accordingly.

Page 19; Last Paragraph: This groundwater elevation estimate does not discuss or present the additional hydraulic head pressure exerted by up to 4+ ft of tidal water over the ground surface every day.

Page 20; Section 5.0; First Paragraph: There is evidence that clearly shows the Camano Island Upland hydrostratigraphy does not extend under Leque Island to a depth of 200’, thus there is no justification for the use of the GS model.

Page 20; Section 5.1: Can the model be run to represent seasonal tidal variation? If so, it should be run if it would provide more realistic estimates of groundwater influence from Leque Island to Camano Island.

The area of the total model domain seems too large.

Page 20 and 21; Section 5.2: Upward vertical gradients were measured at one well immediately adjacent to a drainage ditch. Are these representative of the entire study area?

There have been no measures of drainage from the various sites. So how was it determined that discharge to drainage ditches in the monitoring site "...did not exceed general field observations." What were the general field observations and how do the support/allow this statement?

Page 21; Section 5.3: it is disingenuous to say the restoration doesn't change groundwater flow patterns. Pre-restoration groundwater elevations on Leque Island were less than the monitoring area, thus current predominant groundwater flow is generally eastward from the monitoring site. Under the Leque restoration scenario groundwater will be flowing westward from Leque Island into the Sole Source Drinking Water Aquifer.

In the first bulleted item, please clarify that the predicted flow is to the "monitoring site lowland" and not the Leque lowland. The monitoring site lowland is within the

The last paragraph of the section is very carefully worded. What it doesn't say is that under restoration conditions saline groundwater will be flowing into the Island County Sole Source Drinking Water Aquifer. Essentially, as modeled under the potentially non-protective conditions brought forth in the comment above, bringing salt water to within a few feet of the Camano Island uplands.

These conclusions are very critically reliant on discharge of all groundwater from surrounding areas flowing to a central area monitoring area lowland, then flowing upward, and completely discharging to the drainage ditches of the monitoring area. It is also reliant on modeled groundwater elevations east of the purported "discharge" area underlying Camano Island uplands, in an area that is between only two wells that are one half mile apart. And evidence from wells west of this purely modeled groundwater elevation area was not included for comparison.

Thus, we conclude that the sole source drinking water aquifer has been illegally impacted by the restoration, and more hydrogeological data is needed for the area between the McIntyre and Oksendahl wells and for purported drainage ditch discharge, before any conclusion can be drawn regarding restoration impacts to current drinking water well locations.

And very importantly, the model included Camano Island upland Aquifer D drawdown only surrounding wells that were over a mile away from the monitoring area. It did not account for additional residential well development in close proximity to the critical modeled 'lowland' groundwater collection area near well N3S, and did not consider residential withdrawal as a potential drawdown because of the assumption that all residential and irrigation removal goes to a septic tank or the ground and becomes a 1:1 removal to recharge into the same aquifer the groundwater was removed from (this without consideration of several documented impermeable layers between the surface and Aquifer D).

What are the predicted salinities in the groundwater underlying the monitoring area?

Page C-3; Boundary Conditions; Third Paragraph; Last Sentence: Evapotranspiration rates seem high for a system that is covered by water (tides) a significant portion of the year.

Page C-4; Boundary Conditions: Second Full Paragraph on Page: Why are K_{dr} values for drainage ditches up to twice as high as the river?

Table 3-1: The Oksendahl and McIntyre wells are both shown to have groundwater levels at 6.86 to 7 ft NAVD88. Groundwater on Leque was modeled to be at 7 ft., with inappropriate drain cells and all tidal water modeled as running off above 7.1 ft. It seems adjustment of these model factors could raise the modeled head level on Leque Island well above 7 ft NAVD88.

Figure 3-2: This figure suggests salinity on Leque Island will be in the range of 16 to 18 psu. This figure is not useful in that it does not show the island under restoration conditions.

Figure 3-3: How is it that groundwater is higher in the south wells than in the north wells on the monitoring site, but water levels in the south ditch are 0.6 to 0.7 ft lower than in the north ditches. Also, the Leque ditch data is only available for one month during a drier time of the year. Weren't we supposed to have a year's worth of data?

Figure 3-5 uses umhos/cm and umhos is used in the footnote on Page 7 of the report, but usiemens/cm is used in Figure 3-17 and in other parts of the report. These are the same measure with different names...but please make consistent.

Figure 3-9 greatly exaggerates size of the study area

Figure 3-10 conflicts with distinct layers shown in Figure 3-9 for eastern Camano island because deeper Leque Island well geology on Figure 3-10 shows sands and gravels to depths greater than 200' with no aquitard as shown on Figure 3-9 between Aquifers C and D at depths of approximately 60' and 120' below sea level. Thus, 3-9 is too generalized to represent actual details of the Leque to Camano geology and hydrogeology. Lack of a clear aquitard underlying Leque, to a depth greater than 200' below sea level suggests westward movement of groundwater from the mainland to Camano Island is entirely possible, potentially providing recharge for Aquifers B, C, and D underlying Camano Island. Alternatively, there may not be an accurate understanding and portrayal of the aquifers underlying northeast Camano Island, in which case the groundwater may be continuous down to nearly 200' below sea level.

Figure 3-12: Leque sample taken two weeks after the other data? There is no correlation whatsoever between the Leque well and other wells in this figure given the difference in collection date. Presenting this for comparison to data collected two weeks earlier is inappropriate. The Leque data point should be "not collected" on this figure.

Figure 3-13 suggests N1 and N2 flow toward N3 and during high groundwater elevations S1 and S3 flow toward S2, but in the drier times of the year, S1 and S2 flow toward S3, and all the groundwater generally would flow toward N3 in the central eastern portion of the study area. The relative change in elevation at S3 compared to all other wells suggests a localized influx of water. It would seem most likely this influx is due to surface or very shallow subsurface flows, possible flowing off of the top of the Camano bluff to the east. But this seasonal mound of groundwater at S3 can't continually stop the indicated eastern flow of groundwater from Leque Island toward Camano Island. Thus, it seems possible/likely that similar to N3, there is a vertical recharge occurring in the vicinity of S3 following the wettest times of the year, but yet the predominant groundwater flow at depth may be eastward, particularly during drier times of the year.

The above summary of Figure 3-13 is consistent with the groundwater model results shown in Figure 5-2 and 5-3, which shows all the groundwater from surrounding areas is flowing toward

the vicinity of N3. This groundwater cannot all be flowing toward the same spot without it going somewhere...again substantiating a potential recharge area.

Three months are missing from the data. In particular, the lowest groundwater levels of the year are missing, including the Oksendahl well. After restoration, the groundwater on Leque will be above 7 ft NAVD88, essentially all year around. Therefore, during three to four months out of the year, water on Leque Island will be above levels in the Oksendahl well, which is shown as having higher groundwater than other residential wells farther west on Camano Island.

Figure 3-15 shows that daily (presumably tidally influenced) groundwater fluctuations are greatest on Leque Island and near Davis Slough, reduced to zero inland at the Oksendahl well. This pretty strongly suggests that by allowing seawater to overflow Leque Island, the groundwater level will increase noticeably, thus increasing the current indication of flow toward Camano Island. Because the seawater overflow is salty, the water flowing into groundwater and toward Camano will be salty water.

Well N3S has all the water in the whole study area flowing toward it, but it only fluctuates 0.08 ft. even though surrounding wells fluctuate up to a foot. How is this possible?

Figure 3-18: Why is the range of Davis Slough EC provided as 3-15, but a footnote provided that EC ranged to 25 in Davis Slough. Shouldn't the range just be shown as 3-25? Using mili Siemens here versus micro Siemens elsewhere is confusion...please make these consistent.

Figure 3-19 presumably shows laboratory determined salinity/ions, from which the EC to salinity ratio was calculated. However, the lab determination shows N3S, S1D and S1S as essentially identical and quite similar to S2S, but the EC values for these sample locations in Figure 3-17 show differences of over 20,000 micro Siemens. Then, in N1S, N2S, N3S, S1S, and all ditches except north have EC values higher than the highest shown for Davis Slough. Where is this salinity coming from? It seems EC values are very poorly correlated to salinity and should not be used for any conclusions regarding salinity. Nowhere is it reported what the actual salinity was in these samples. Please provide explanation for %mEQ/L and how it converts to salinity.

Figure 4-4: The modeled high tide stage is about one-half a foot below mean higher high tide. It seems a conservative use of mean higher high tide would have been more appropriate. More specifically, what was the rationale for the tide stage model input selection?

It is stated that all drainage ditches will be filled except the middle "relic" channel. The bottom of this channel bottom is listed as 4.5 ft NAVD88; why is 3.8 used as a "ditch" bottom?

Figure 4-5: Earlier in the document it was stated that the Geodesign borings had groundwater at or very near the surface. Therefore, the approximate range of groundwater levels under current conditions seems to be a bit low. Also, essentially what this figure supposedly shows is that future recharge is no different than current? Flooding will not change the recharge? Won't up to four feet of seawater over the top of the land create a higher hydraulic head pressure than no water?

Figure C-1: the ditches on Leque are going to be filled and therefore should not be drain cells.